Active Galactic Nuclei: from Central Engine to Host Galaxy
ASP Conference Series, Vol. xxx, 2003
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The production mechanism of radio jets in AGN and quasar grand unification

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Abstract. Recent advances in estimating black hole masses for AGN show that radio luminosity is dependent on black hole mass and accretion rate. In this paper we outline a possible scheme for unifying radio-quiet and radio-loud AGN. We take the "optimistic" view that the mass and spin of the central black hole, the accretion rate onto it, plus orientation and a weak environmental dependence, fully determine the observed properties of AGN.

The production of powerful radio jets There is good observational evidence that radio jet power is closely linked to both the mass of the black hole and its accretion rate. Links between the mass of the black hole and its radio luminosity have been found in both radio-weak elliptical galaxies (Franceschini, Vercellone & Fabian 1998) and quasars (Laor 2000; Lacy et al. 2001; Boroson 2002). Essentially all steep-spectrum radio-selected quasars and BLLac objects have black holes more massive than $\sim 10^8 M_\odot$ (e.g. McLure & Jarvis 2002; Barth, Ho & Sargent 2002; O'Dowd, Urry & Scarpa 2002), and all powerful radio galaxies exist in massive hosts, almost invariably giant ellipticals. Recent claims that a significant fraction of flat-spectrum radio-luminous quasars have black holes $\sim 10^{6-7} M_\odot$ (Oshlack, Webster & Whiting 2002), have been questioned by Jarvis & McLure (2002) on the basis of orientation biases.

Radio luminosity is roughly linearly correlated with accretion rate for quasars (e.g. Lacy et al. 2001). At low accretion rates (in the ADAF regime), however, black holes seem to be able to deliver more radio jet power than expected if the linear correlation continues to low accretion rates, i.e. low luminosity AGN tend to be radio louder than most quasars (Ho 2002).

Most models predict than black hole spin should be important for determining radio jet luminosity. Indeed, the residual scatter of radio luminosity about the best-fit combination of black hole mass and accretion rate (a radio "fundamental plane") is 1-2 orders of magnitude, and probably not just due to measurement error, suggesting that spin, and/or some other parameter(s) need to be taken into account. Recent results from a study of the Fe Kα line in MCG-6-30-15 indicates that the black hole in this radio-quiet Seyfert galaxy may be spinning rapidly, however (Fabian, these proceedings).

Broad absorption line quasars The fraction of highly radio-luminous BALQs is small compared to that in samples of radio-quiet quasars. If broad absorp-

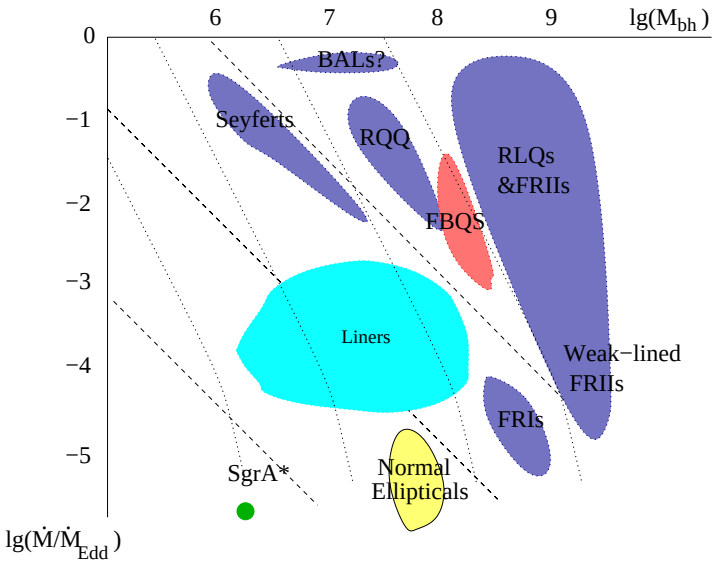

Figure 1. A tentative AGN grand unification scheme. Orientation should be thought of as another, orthogonal axis in this plot. Lines of constant radio luminosity are shown dotted, lines of constant accretion (optical) luminosity are shown dashed.

tion lines are only seen in objects accreting close to the Eddington rate (Boroson 2002), then this might be explained as a selection effect. Most radio-loud quasars have high black hole masses, thus a radio-loud quasar accreting at near the Eddington rate would be highly luminous, and hence very rare.

Acknowledgments. I thank Aaron Barth and Mike Brotherton for helpful discussions. This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

References

Barth A.J., Ho L.C., Sargent W.L.W., 2002, ApJ, in press (astro-ph/0209562)

Boroson T.A., 2002, ApJ, 565, 78

Franceschini, A., Vercellone, S., & Fabian, A.C. 1998, MNRAS, 297, 817

Ho, L. 2002, ApJ, 564, 120

Jarvis M.J. & McLure R.J., 2002, MNRAS, submitted (astro-ph/0208390)

Lacy, M., Laurent-Muehleisen, S.A., Ridgway, S.E., Becker, R.H. & White R.L. 2001, ApJ, 551, L17

Laor, A. 2000, ApJ, 543, L111

McLure, R.J. & Jarvis M.J. 2002, MNRAS, in press (astro-ph/0204473)

O'Dowd M., Urry C.M., Scarpa R., 2002, ApJ, in press (astro-ph/0207597)

Oshlack, A.Y.K.N., Webster, R.L. & Whiting, M.T. 2002, ApJ, 576, 810